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REDUCING DEFECTS IN HORN ASSEMBLY LINE THROUGH IMPLEMENTATION OF LEAN TOOLS

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Abstract - Now a day's most of the organization are shown keeping interest in using six sigma approaches to improve their performance. Motorola coined the concept of Six Sigma and General Electric Popularized it. This paper focus on minimizing the spool arm defects in a horn manufacturing industry using Six Sigma methodologies. Here in, use of Six Sigma methodologies is tried out in a typical process industry for reduction of defect levels. The tested horn coming out of the horn tuning stage is found to have defects at random times causing horn losses there by impacts a revenue loss to the company. Rejection rate of spool arm defect has been reduced and sigma level of process is increased.

Keywords: Six Sigma, DMAIC, Defects per Million Opportunities (DPMO).

I. Introduction

"Sigma" or σ is a Greek letter that denotes the standard deviation of a random variable. Traditionally, Six Sigma is a number used to represent the range of values of a population with normal distribution as mathematically, 99.73% of all values can be expected to fall within a range that extends from three sigma less to three sigma higher than the population mean. In the last fifteen years, "Six Sigma" has been known as an initiative for quality improvement and more broadly, business excellence. Six Sigma as a new opportunity for any organization that wants to improve quality. The main cause of quality problems is basically variation. To improve quality, variation must be measured, reduced, and prevented. Generally, Six Sigma is a top-down initiative carried out by a hierarchy of trained personnel designated as Champions, Master black belt, Black belts, Green belts and so on, each designation reflecting the level of competenence with respect to level of DMAIC Knowledge and Practice.

II. Literature Review

Six Sigma has the ability to produce products and services with only 3.4 defects per million, which is a world-class performance. Six sigma has also been described as a high performance data- driven approach in analysing the root causes of business problems and solving them.

Wenny Chandra, key success factors for six sigma implementation .There are several factors that make six sigma an increasingly popular quality imitative, even more so than the past TQM, ISO, Zero Defect and so on. These factors are also determinants as to weather a six sigma program will lead to significant improvements [1].

Prasada Reddy, process improvement using six sigma in small scale industry to improve their operations performace.The study was conducted in bearing manufacturing unit. Improvement in the process. Rejection rate of bearing rings has been reduced [2].

Yousef Gholipour, study was conducted in automobile industries different phases of this project were studied and its success and failure rates were identified, the relation between the execution of control phase success and failure rate were identified finally solution are suggested.

Six Sigma is one of the more recent quality improvement initiatives to gain popularity and acceptance in many industries across the globe. Six Sigma differs from other quality programs in its top-down drive in its rigorous methodology and a control plan to ensure ongoing quality control of a process [3].

Hongbo wang, In recent years there has been a significant increase in the use and development of the six sigma methodology in manufacturing industry and others. Six sigma is a long term commitment . Six sigma changes the way a company thinks by teaching fact-based decision making to all levels [4].

III. Problem Identification

In this project, we have analysed the manufacturing of SMU0 12V horn through assembly process. Data has been collected for a period of two months, where the production and rejection statistics of the SMU0 12V horn production line are noted. SMU0 12V manufactured in this assembly line experiences a large rejection rate. Maximum number of rejection has been found to be occurring in this assembly process. Hence, SMU0 production line was considered for this work. Six sigma methodologies [DMAIC (Define-Measure-Analyse-Improve-Control)] are proposed to reduce the rejection rate of the manufactured horns. Six sigma and lean tools are employed to solve this problem by means of which a suitable methodology is developed

IV. Six Sigma Methodology

Six Sigma philosophies are based on DMAIC process: Define Measure, Analyze, Improve and control. The problem is stated in the Define phase. The process performance is estimated in the Measure phase to find the present sigma level.Analyze phase is used to find the reason for poor performance. Recommended solutions are implemented in the next phase Improve. Finally control phase is used to find the deviations from the recommended method to the actual progress and reasons for deviations will be analysed. Six Sigma makes use of a collection of quality management and statistical tools to construct a framework for process improvement. The objective is to enhance the sigma level of performance measures that reflect the needs of the customer. Such measures are generally referred to as "critical to quality" or CTQ. CTQ is improved via a systematic as approach of DMAIC, taken on a project-by-project basis. In the Define phase, the problem is captured, and customer impact and potential benefits of the project are assessed. In the Measure phase, CTQs of the product or service are identified measurement capability is assured, current performance as well as improvement goals are determined. In the Analyse phase, root causes of defects are uncovered, and key process variables that may be linked to defects are identified.

The most critical phase of Six Sigma application is Improve, when the influences of key process variables on the CTQs are quantified, acceptable limits of variables are identified, and the process modified to reduce CTQ defect levels. Finally, in the control phase, actions are taken to sustain the improved level of performance and ensure long term gains. The various phases of DMAIC are shown in Table 1.

The major steps involved in DMAIC process are stated as follows:

- Studying and analysing the existing system
- Identification of the problem(s) and factors for higher rejection rate
- Analysis of the factors affecting the component rejection
- Collection of data for a particular time period
- Preparation of Pareto chart
- Development of Cause and Effect diagrams
- Identification of root causes for the rejection of horns

Taking necessary actions to reduce the rejection of horns

TABLE 1

VARIOUS PHASES OF DMAIC

Steps	Key processes
Define	Define the requirements and expectations of the customer Define the project boundaries Define the process by mapping the business flow
Measure	Measure the process to satisfy customer's needs Develop a data collection plan Collect and compare data to determine issues and shortfalls
Analyze	Analyze the causes of defects and sources of variation Determine the variations in the process Prioritize opportunities for future improvement
Improve	Improve the process to eliminate variations Develop creative alternatives and implement enhanced plan

V. Define

The define phase is focused on the detailed description of the problem and stating the goal statements and developing a project charter. The High level process mapping of the machine shop is done with the SIPOC diagram to understand the process steps in a comprehensively.

A. Project charter

- *Project Description*: Reducing the rejection rate of manufactured SMU0 in the horn assembly line using six sigma methodology.
- *Business case*: The improvements obtained by the implementation of the recommended solutions and actions thus reduce the rejection rate of assembled horns and the global risk level of the process. Our proposed solution traces analysis in terms of cost, a widely accepted measure of risk.
- *Problem statement*: The rejection rate for Assembled SMU0 12V horns is high due to Spool arm breakage in Spool holder riveting stage, horn tuning and testing, and Insufficient spare parts in the tool crib area
- *Goal statement:* Reduce the rejection rate due to Spool arm breakage and to control the inventory in tool crib area.

  Need or opportunity - Lower Rejection rate
  Product name - SMU0 Horn
  Key benefit - Higher Quality to satisfy customer
- *Project Scope:*

  Longitudinal (length) – Spool Holder Riveting
  Lateral (Breadth) – SMU0 Horn
- *Functional Members*: Project trainee
- *Supporting Members*: Machine shop supervisors, Tool Crib supervisors, PPC In charge, and Quality In charge.

IV. Measure

In the Measure phase, data on rejection rate of horn defects. Data regarding the horn sound performance which due to spool arm breakage and scratches on the surface. The normal sound (Db) lies between 105-111Db which produces good results. The data is collected at the end of each hour. Five pieces were tested manually during each hour and were inspected. The data collected is given in Table 2.

A. Control charts

A control chart is a graph that displays data taken over a particular period of time and the variations of this data. It is a tool which helps to check whether the process is within control or not and it also helps to evaluate the process stability. There are two types of control charts, namely, variable and attributes control chart. The former is required to determine whether a part is defective. In this study, the variable control chart is used, as the quality characteristic (sound (Db) measured during Testing stage of horn assembly process).

In this project following two types of control charts are used:

1. X or average chart and
2. R or range chart

The chart is used to monitor the centering of the process to control its accuracy and the R chart monitors the precision of the process.

B. X-Chart

From Table 2, the values of Xn, and R are calculated as follows:

Xn=(A+B+C+D+E)/5

Where, A, B, C, D and E are the values of Sound of Five 12V horns randomly tested at each hour.

Mean Value, = Xn/20

Where, n denotes each hour and Xn the value of average of sound measured at each hour.

Range, R= Difference between the maximum and minimum and minimum values among A, B, C, D and E

Mean Value = 107.54 Db

Range R = 8.075 Db

Upper Control Limit (UCL) = +A2R

UCL = 107.54+ (0.577*8.075)

UCL = 112.19 Db

Lower Control Limit (LCL) = -A2R
LCL = 107.54-(0.577*8.075)
LCL = 102.88 Db

TABLE 2

SOUND (Db) OF SMU0 12V TESTED HORNS- EXISTING

Each of each hour	Sound (Db)					Xn	R
	A	B	C	D	E		
1	108	106	105	111.5	110	108.1	6.5
2	109.5	90	107	108.5	96	102.2	19.5
3	93.5	113.5	112.5	107	108.5	107	20
4	110.5	112.5	110.5	109	107	109.9	5.5
5	107	109	109	99.5	110.5	107	11
6	108.5	113.5	101	105	108	107.2	12.5
7	103	108.5	109.5	110.5	102.5	106.8	8
8	105.5	104.5	104	110	106	106	6
9	103	103.5	113	108.5	108	107.2	10
10	104	111	110.5	107.5	111.5	108.9	7.5
11	112	113.5	114	111	111.5	112.4	3
12	109	111	109	107.5	107	108.7	4
13	97	103.5	101.5	104	103	101.8	7
14	109	110	109.5	110	110	109.7	1
15	112	115	113	111	114	113	4
16	102	105	107	108.5	109	106.3	7
17	115.5	109	109.5	109.5	109	110.5	6.5
18	111	107	109.5	108	107	108.5	4
19	102	104	103	105	92.5	101.3	12.5
20	105.5	106	108.5	111.5	110	108.3	6

Chart is drawn using the above values, which is shown in Figure 1

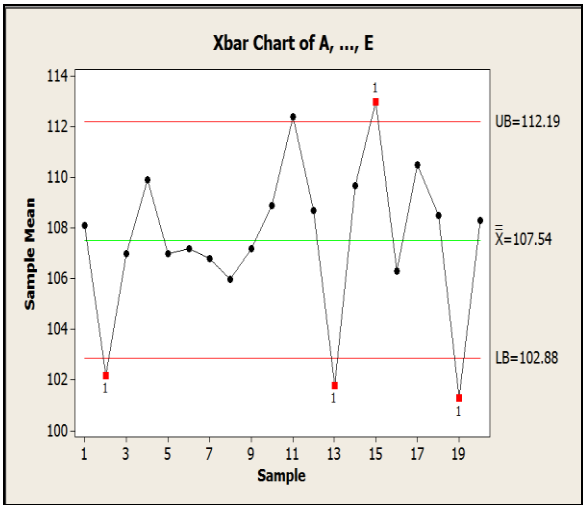

Figure 1: x-chart

C. *R-Chart*

Upper Control Limit (UCL) = D4R
UCL = 2.114*8.075
UCL = 17.07 Db
Lower Control Limit (LCL) = D3R
LCL = 0*8.075
LCL = 0 Db

Limits were calculated using the Johnson Su distribution and the values of A2, D4, and D3 were all taken from the standard values (Jayakumar, 2005). Using the above values, R chart is drawn, which is show in Figure 2.

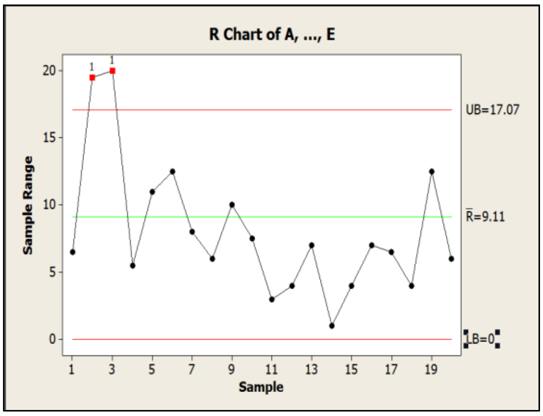

Figure 2: R Chart

From the X and R charts, it is clear that some of the 12V horns manufactured have some defects. Hence, it is required to effectively reason out the causes for these defects.

D. *Six Sigma Level Calculation*

Six sigma allows the mean to shift at most by 1.5 from the specification midpoint (Yang, 2004). If the process is centred midway between the specification limits, i.e. no shift in process mean, the defect rate is 0.001ppm. In order to get a more achievable target, the process is shifted by 1.5 from the specification midpoint.

Data had been collected for a period of two months and the following were noted in the SMUO12V horn production line:

Total number of units inspected = 62500
Total number of defectives observed = 466
Defects per unit (DPU) are calculated as follows:
Defects per unit (DPU) = Total no. of defectives observed/Total no. of units inspected
DPU = 466/62500
DPU = 0.007456
Then defects per million opportunities are calculated as follows:
Defects per million opportunities (DPMO) = DPU*1,000,000
DPMO = DPU*1,000,000
=0.007456*1,000,000
DPMO = 7456ppm
From Six Sigma Table, i.e. the standard sigma to DPMO conversion table, the corresponding sigma value can be obtained by interpolating between the nearest two defect rates. For DPMO = 7456ppm, the sigma value was found to be 3.93.

VII. Analyse

From the calculation of defects per million opportunities, the defect rate of the process has been found to be 7456ppm. It corresponds to only a 3.93 value. This needs to be rectified by means of finding the major cause for the defects. One commonly used diagnostic tool for identifying the major defects is the Pareto diagram.

A. *Pareto Diagram*

Pareto diagram is a diagnostic tool commonly used for separating the vital few causes that account for a dominant share of quality loss. It is based on the Pareto principle, which states that a few f the causes accounts for most of the defects. This analysis is used to prioritize causes based on its relative importance. In this project most of the inspected units were found to be rejected because of the causes shown in the Pareto diagram. It is illustrated in Figure 3.

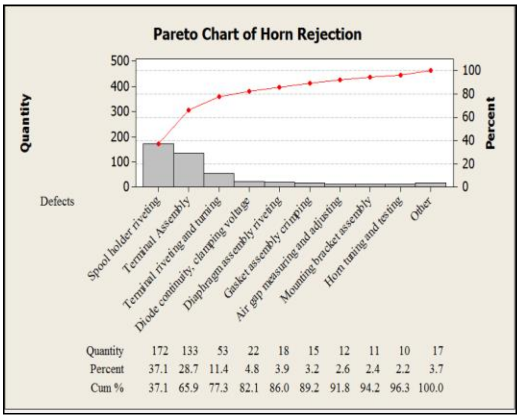

Figure 3: Pareto Diagram

From the Pareto diagram, it was found that the major defects of the Horn Assembly process were due to spool arm breakage, terminal assembly, terminal riveting, and diode continuity. The causes for the major defects were identified and represented using the cause and effect diagram as shown in the Figure 4.

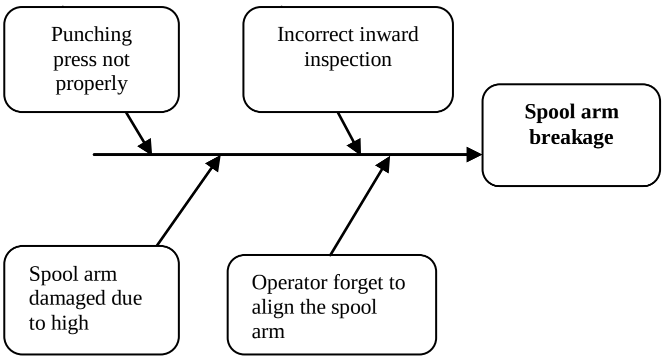

Figure 4: Cause and effect diagram

VIII .Improvement

Problem	Solution
Spool arm breakage	Sliding pin or compression spring pin

We start with the spool holder riveting process assuming introducing a new sliding pin here will eliminate the 1st problem and changing the maintain the inventory will reduce the reduce the 2nd one. The reason for introducing the sliding pin in the spool holder riveting process is to have all the housing assembled horns have to be riveted, without making breakage and scratches on the spool arms. But due to high physical stress and poor handling, few breakages happen. So, the assembled horns are rejected at the end of the production line.

A. *Modified Process*

The housing assembly is joined with Spool arm and placed in Spool Riveting fixture and then the operator aligns the spool arm in right hand and presses the control button using left hand and finally inspected before dispatching.

- Now, the spool arm is joined with housing assembly initially
- Then the riveting screws are attached to it..
- The operator loads the connected parts in the spool riveting fixture and presses the control button.
- Spool riveting machine performs the operation with the newly designed sliding pin, after completion of the process the operator unload from the fixture.

In Spool arm riveting process the newly designed riveting fixture with spring is shown below.

Figure 5. Spool arm

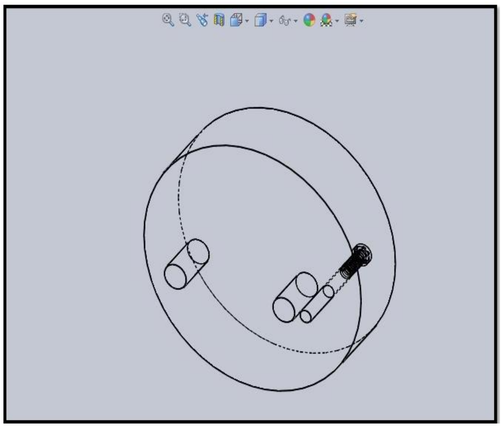

Figure 6 . Riveting Fixture with sliding pin

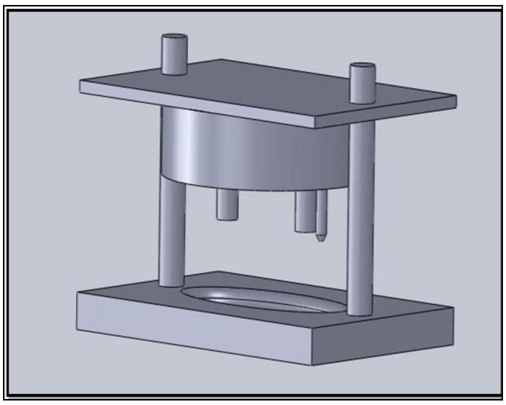

Figure 7.Riveting Fixture for Spool arm riveting process

B. X and R Chart

Chart is drawn using values, which is shown in Table 3.

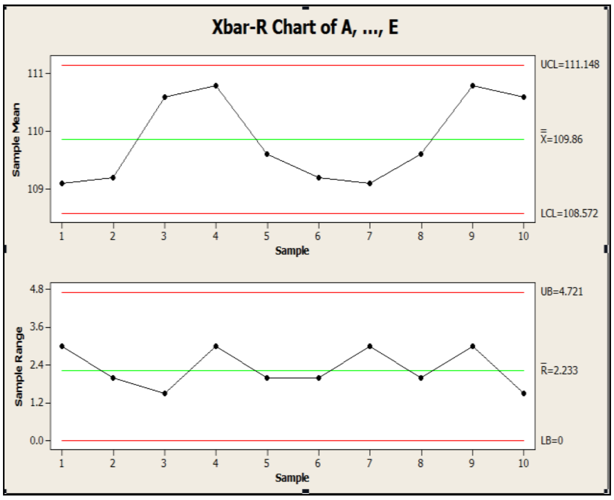

Figure 8 X and R Chart

From the X and R charts, it is clear that the SMUO 12V manufactured horns are free from defects.

TABLE 3

SOUND (DB) OF SMUO12V TESTED HORNS-AFTER

Each of each hour	Sound (Db)					Xn	R
	A	B	C	D	E		
1	108.5	107.5	109	110.5	110	109.1	3
2	109.5	110	108	108.5	110	109.2	2
3	110	110	111.5	111	110.5	110.6	1.5
4	110.5	112.5	110.5	109.5	111	110.8	3
5	108.5	109	110	110	110.5	109.6	2
6	109.5	110	108	108.5	110	109.2	2
7	108.5	107.5	110.5	110	109	109.1	3
8	109	108.5	110	110.5	110	109.6	2
9	112.5	110.5	110.5	111	109.5	110.8	3
10	111.5	110	110	110.5	111	110.6	1.5

IX. Kaizen Activity

The kaizen group studied the Current state map onto the SMU0 12V assembly line. A set of kaizen activities initiated and implemented in effort to optimize the productivity of the assembly line as shown in figure 9. The assembly process is monitored and during the monitoring phase, continuous evaluation on any discrepancies or imperfections on product are being addressed immediately. Necessary counter measures are made to ensure the effectiveness of the manufactured horns and line productivity stability is achieved.

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Figure 9. Before After

X. Conclusion

A case study has been made in a real industrial background where quality tools are effectively used for the reduction of rejection rate. Quality tools like Control charts, Cause and effect diagram, Pareto diagram were employed to develop a methodology to identify the influencing factors for defects in SMUO12V horn production. The Pareto chart shows the visual impact of the underlying causes for defects occurring in the SMU012V production line. It sorts out the various causes for the defects according to its importance. Cause and effect diagram helps to identify the possible causes for the defect in the manufactured horns. The design and manufacturing of the Spool arm riveting with sliding pin gives the rectification method that can be used to reduce the defects in the breakage of spool arm in the assembled horns. The design of spool arm sliding pin helps even a semiskilled operator to easily operate and reduce the rejection rate. The kaizen activity in the critical spares inventory control provides the solution, reduces the lead time and increase the productivity.

XI. References

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